

Estimation of Projects in Contexts of Uncertainty

EPCU

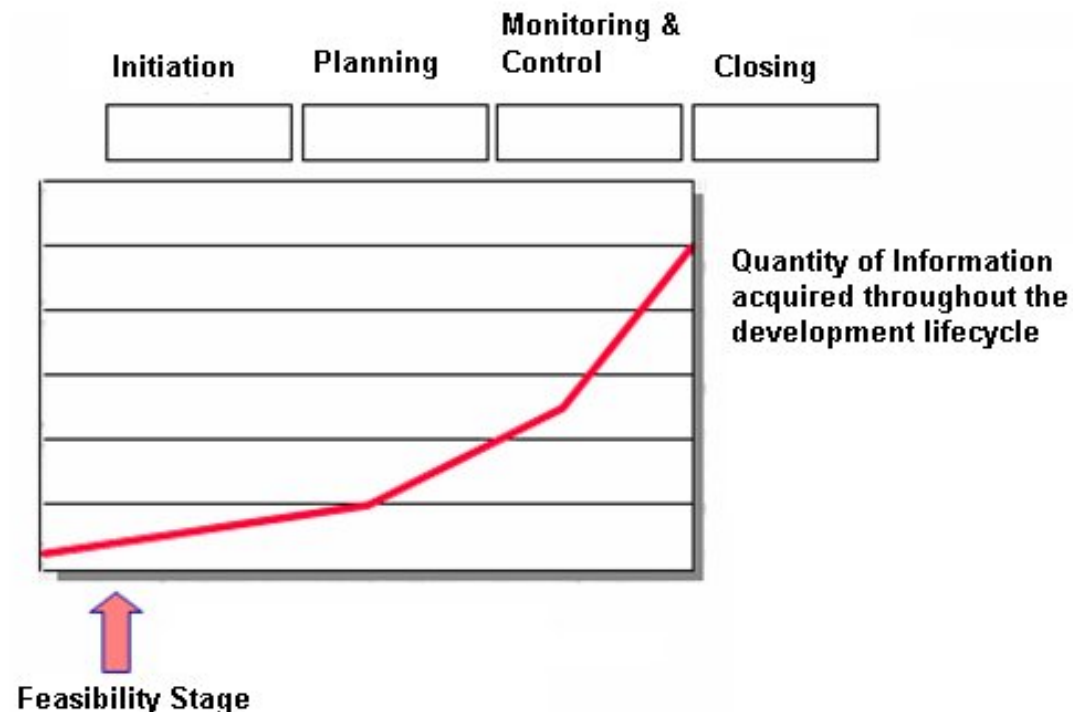
Francisco Valdés (Mexican Central Bank),
Alain Abran (École de technologie supérieure –
Université du Québec)

Objective

- To report on the actual use of the estimation model EPCU (estimation under uncertainty) through two case studies in two different organizations.

The Problem

- At the feasibility stage, most of the information is available only at a very high level of abstraction, and is often based on a number of assumptions which can be neither verified nor precisely described.



The Problem

The decision to launch a project is often determined by:

- considering in particular the “subjective” importance of the outcome, that is, delivering the product (a system),

while at the same time

- subjectively minimizing that it may not be possible to do so on time because of a lack of certainty on most of the elements identified and assessed in the feasibility analysis.

Experience-based Estimation

- Estimation technique typically used in industry: the one based on the experience.
- Some problems using this approach:
 - experience is specific to the expert and not to the organization;
 - estimation expertise is neither well described nor well understood;
 - this expertise is hard to assess and cannot be replicated systematically.

Experience-based Estimation

- However, estimation expertise is still valuable to an organization.
- The challenge is to figure out how to benefit from it, i.e. defining an estimation model which takes into account characteristics such as:
 - the way practitioners make their estimates;
 - the (qualitative) variables that practitioners use;
 - the uncertainty associated with the project schedule in the early stages of the life cycle using the information available at the time (often vague or ambiguous).

EPCU

- Software development organization in Mexico: an estimation model based on fuzzy logic developed to take into account:
 - the estimation inputs and outputs of experienced practitioners in the estimation process.
 - Estimation model is referred as Estimation of Projects in Contexts of Uncertainty - EPCU.
 - by considering qualitative variables as experienced practitioners use them in making estimates.

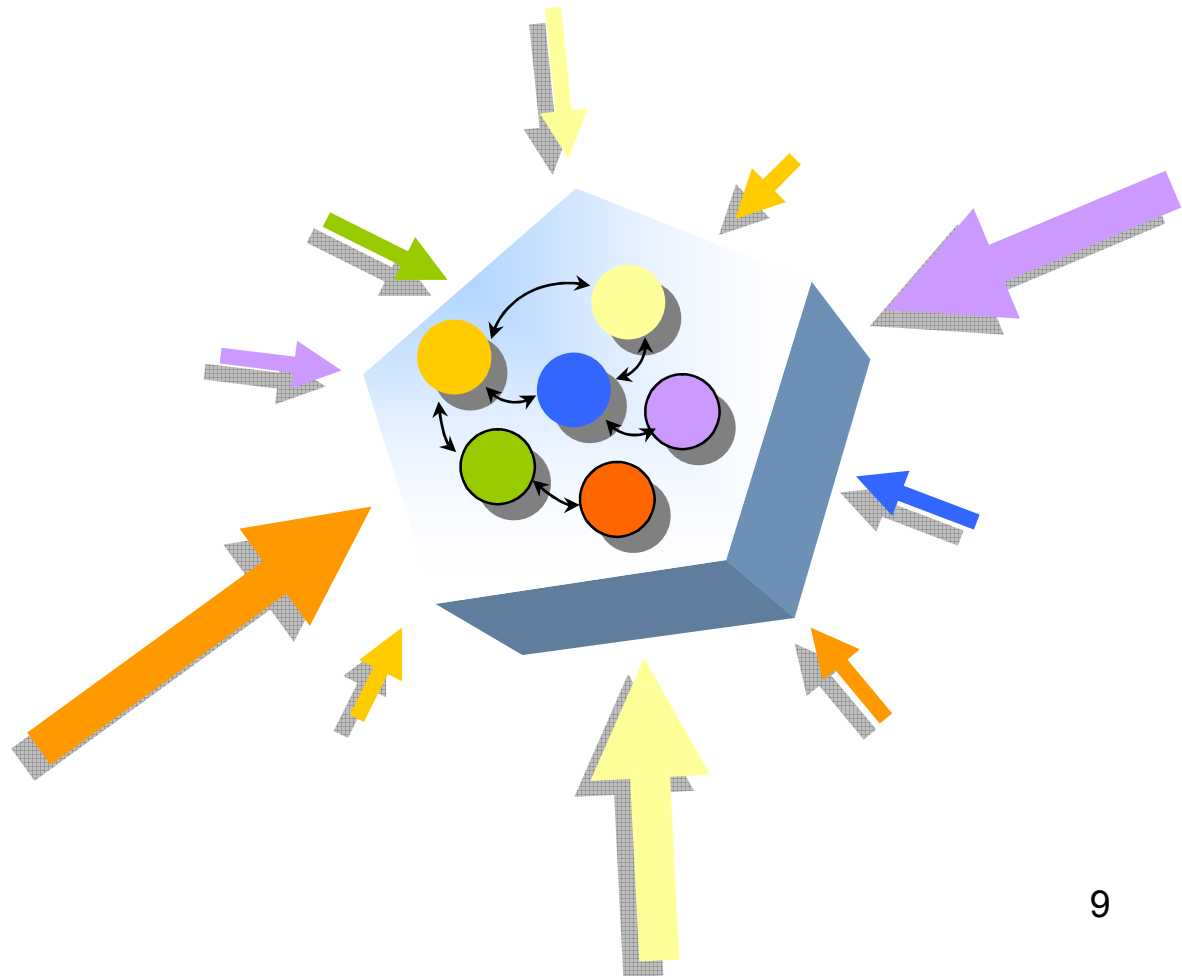
EPCU Concept

“The Uncertainty: it is not possible to measure it , however it is possible to contextualize it”

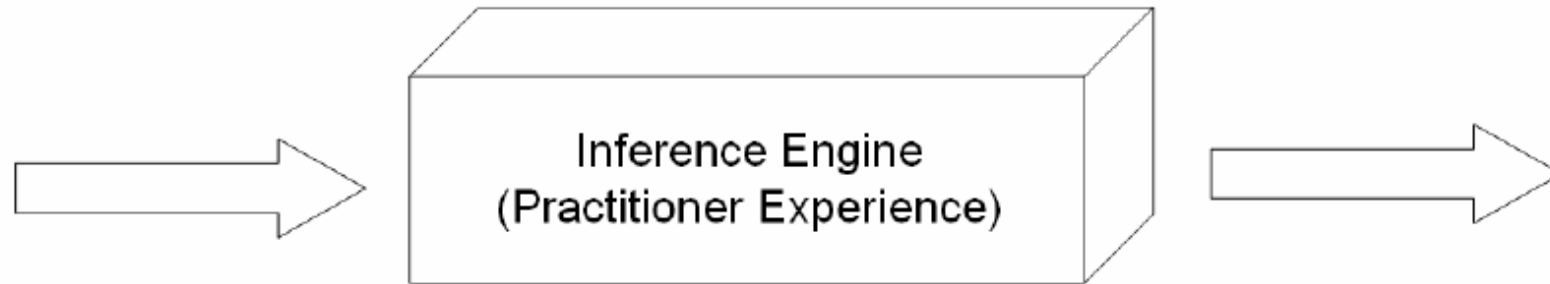
EPCU Concept

□ All the variables that affects the duration for a specific project has distinct magnitudes and impacts.

□ If we have the possibility to consider ALL the variables affecting a specific project, maybe the estimation about the duration could be more accurate, but this is NOT POSSIBLE. So the consideration is to identify the most weighted variables to estimate.



EPCU



Input Variables:

- Complexity
- Duration
- Size
- Tool Development Experience
- Work Team Motivation
- Process Development Experience
- Knowledge of the kind of systems to develop
- Project leadership skills
- Risks
- Etc.

Output Variables

The EPCU Steps

- The EPCU model includes six steps:
 1. Identification of the input variables,
 2. Specification of the output variable,
 3. Generation of inference rules,
 4. Fuzzification,
 5. Inference rules evaluation
 6. Defuzzification.

The EPCU Steps

1. Identification of the Input Variables
 - The goal of this step is to have the experienced practitioners in an organization identify and assess the most significant variables for a project or kind of projects, for instance
2. Specification of the Output Variable
 - The previous step is repeated for the output parameter (here, the estimate of the project duration).

The EPCU Steps

3. Generation of Inference Rules

- All the fuzzy sets belonging to each input variable must be combined in 'if..., then...' form to generate the rulebase:

If x and y, then z

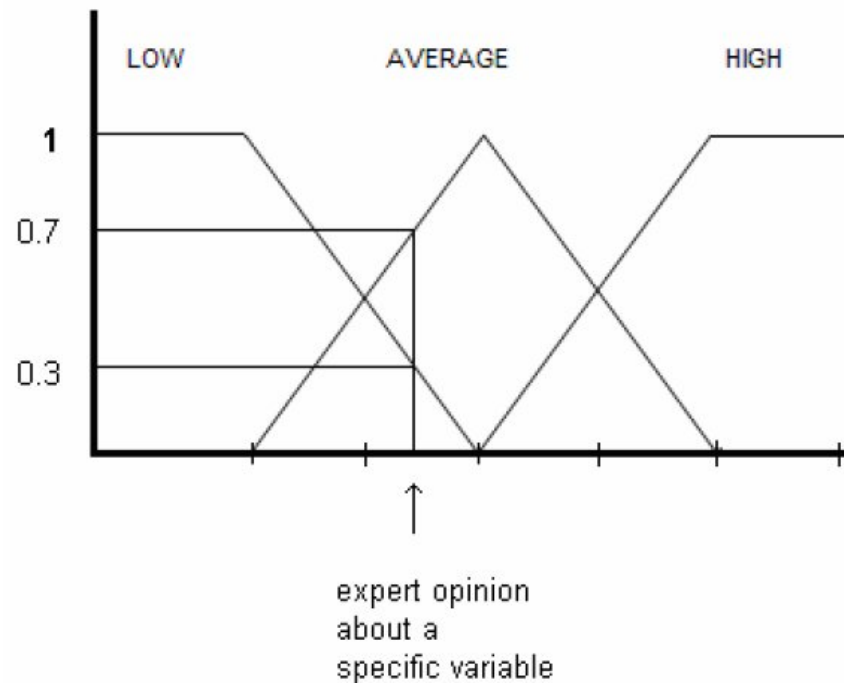
If x or y, then z;

where “x” is a fuzzy set for one input variable, “y” is a fuzzy set for another input variable and “z” is the fuzzy set for the output variable.

The EPCU Steps

4. Fuzzification

- The goal of this step is to obtain fuzzified values as a consequence of opinions as to those values put forward by an experienced practitioner.



The EPCU Steps

5. Inference Rule Evaluation

- This step consists of evaluating the rulebase by substituting the fuzzy values obtained. The Inference Rule evaluation must follow the rules of fuzzy logic, such as:

$$\text{Value (P or Q)} = \max \{ \text{value (P)}, \text{value(Q)} \}$$

$$\text{Value (P and Q)} = \min \{ \text{value (P)}, \text{value(Q)} \}$$

The EPCU Steps

6. Defuzzification

- The sixth step consists of defuzzification, in order to obtain a crisp value for the final estimate.

Case Studies

- The EPCU model was tested in two different software organizations:
 - Software developed for external clients developing software packages
 - a financial services organization which develops software for its own needs.

Case Studies

- These two organizations are relatively small and considered representative of typical software development organizations in Mexico where 80% are small organizations

Size of software organizations in Mexico

Size	Workers	Workers Average	Organizations
Very Small	Less than 15	7	63
Small	16 to 100	60	117
Médium	101 to 250	175	14
Large	251 to 1000	600	11
Corporation	More than 1000	1500	1
Total			206

Considerations driving the EPCU

- Use the Case Study methodology
- For each organization where the EPCU model was used, face-to-face interviews were conducted for case study 1 with the project manager and the rest of the team, and, for case study 2, with the project coordinator only.

Case Study 1

<u>Features:</u>	<u>Variables:</u>	<u>Project Duration:</u>
<ul style="list-style-type: none">•Small Enterprise•SW B2B•Software Development Process•Actual Duration: 1 year 4 months•Estimated Duration without EPCU: 6 months	<ul style="list-style-type: none">•SW Size (Small, Average, Large)•Functional Complexity (Low, Average, High)•Software Development Process Familiarity (Low, Average, High)	<ul style="list-style-type: none">•Short, up to 2 months•Average, approx. 6 months•Large, approx. 12 months•Very Large, up to 24 months

Case Study 1

Case Study 1: estimation outcomes and comparisons

	Software Size	Functional Complexity	SW Development Process Familiarity	EPCU Estimation	Actual Duration - EPCU Estimation	% underestimation	% overestimation
EXPERT 1	3	3	1	14.9	1.1	7%	
EXPERT 2 (Project Manager)	3	2	1	11.4	4.6	28%	
EXPERT 3	4	3	1	19.3	-3.3		21%
AVERAGE	3.3	2.6	1	16.0	0.0	0%	
Actual Duration	16						
Original Estimation	6						
Underestimation	63%						

Case Study 1

- For illustrative purposes only, the following assumptions are made: the whole project is developed by a single developer who works 8 hours a day (or 160 hours in a month considered to be made up of 4 weeks) at a cost per hour of approximately \$120 US\$/hour).

Case Study 1

Case Study 1: Impact of estimation errors

	EPCU Estimation	COST (with assumptions) [USD]	Losses	Profits
ACTUAL COST		\$307,200.0	\$0.0	
COST CONSIDERING ORIGINAL ESTIMATION		\$115,200.0	\$192,000.0	
COST CONSIDERING EPCU ESTIMATION	14.9	\$286,264.3	\$20,935.7	
	11.4	\$219,742.1	\$87,457.9	
	19.3	\$371,420.2		\$64,220.2
	16.0	\$306,451.2	\$748.8	
Actual Duration	16			
Original Estimation	6			
hrs/months	160			
USD / hr	\$120.00			

Case Study 1

Case Study 1: Estimation outcomes and comparisons by students

	Software Size	Functional Complexity	SW Development Process Familiarity	EPCU Estimation	Actual Duration - EPCU Estimation	% underestimation	% overestimation
STUDENT 1	4	4	3	16.5	-0.5		3%
STUDENT 2	3	4.5	3	13.6	2.4	15%	
Actual Duration	16						
Original Estimation	6						
Underestimation	63%						

Case Study 2

<u>Features:</u>	<u>Variables:</u>	<u>Project Duration:</u>
<ul style="list-style-type: none">•Internal Area•Client/Server SW•Maintenance•No Experience with the Development Tool•2 individuals (one was new in the area)•Actual Duration: 9 months•Estimated Duration without EPCU: 4 months	<ul style="list-style-type: none">•SW Size (Small, Average, Large)•Experience Developing Similar Applications (Low, Average, High)•Experience with the Development Tool (Low, Average, High)	<ul style="list-style-type: none">•Short, less than 3 months•Average, 4 to 10 months•Large, approx. 11 months•Very Large, up to 17 months

Case Study 2

Case Study 2: Estimation inputs and outcomes

	Software Size	Experience Developing Similar Applications	Development Tool Experience	EPCU Estimation	Actual Duration - EPCU Estimation	% underestimation	% overestimation
Coordinator	2	3	0	9.3	-0.3		3%
Actual Duration	9						
Original Estimation	4						
Underestimation	56%						

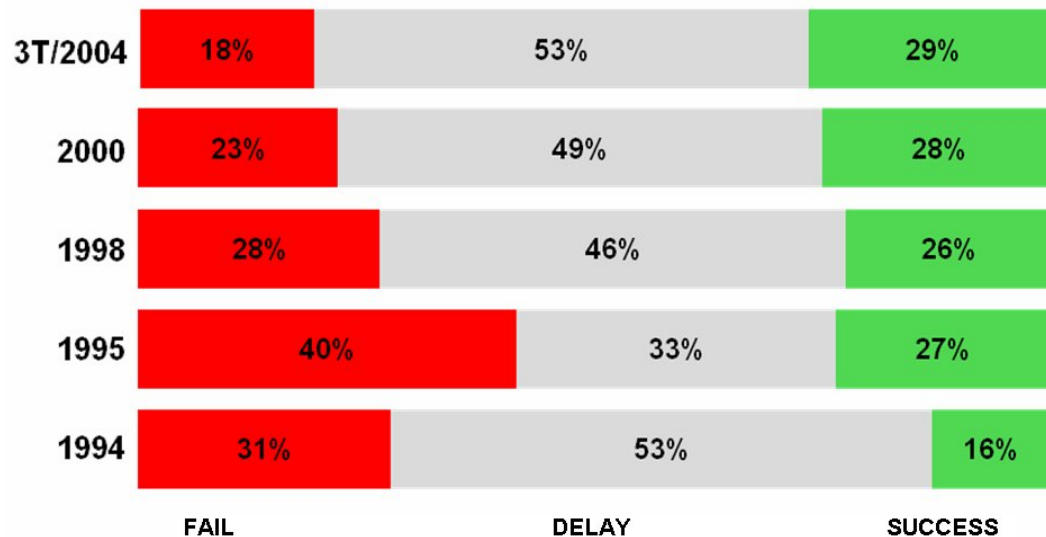
Case Study 2

Case Study 2: Impact of estimation errors

	EPCU Estimation	COST (with assumptions) [USD]	Losses	Profits
ACTUAL COST		\$172,800.0		
COST CONSIDERING ORIGINAL ESTIMATION		\$76,800.0	\$96,000.0	
COST CONSIDERING EPCU ESTIMATION	9.3	\$178,560.0		\$5,760.0
Actual Duration	9			
Original Estimation	4			
hrs/months	160			
USD / hr	\$120.00			

Discussion

- For case study 1, the estimated duration which was the basis on which management gave the go-ahead and on which the sale price was calculated, was 6 months; the actual duration was 16 months, that is, an underestimation of 10 months, or 63% over the original estimate. Underestimation of this magnitude is common in industry, as illustrated in the Standish Group report



The Standish Group International, *Extreme Chaos*, The Standish Group International, Inc., 2000-2004 Research Reports

Discussion

- The impact of projects with costs over budget and schedule delays is a :
 - loss for the organization that asked for the product. In addition,
 - this underestimated project would most likely have deteriorated the organization's relationship with the supplier of the software.
- By contrast to the estimate originally based only on the practitioners' experience in the case study 1, the proposed EPCU model would have enabled the generation of multiple estimation scenarios with, even in the worst-case scenario, an *under-estimated duration of 4.5 months, or 28%* which represents about half the delay experienced in reality.
- With the best estimate obtained using the scenario with averages of the inputs estimates, there would have been almost no delay and no additional cost.

Discussion

- In case study 2, the estimated duration which was the basis on which management gave the go-ahead and on which the cost was calculated was 4 months, while the actual duration was 9 months, which amounts to an under-estimation of 5 months, or 56%.
- The duration estimated using the EPCU model was closed at 9.3 months, that is, only 3% over actual project duration. In this case the project would have generated a profit and not the loss that occurred.

Discussion

- For case study 2, the original estimate of duration was made by the same person who made the estimation of the inputs to the EPCU model. This individual had identified the input variables required to define the model for his organization, which illustrates that it is not easy, even with the same experienced individuals doing the work, to systematically replicate estimates.
- The proposed EPCU model would have enabled the generation of multiple estimation scenarios easier and systematically than only use the practitioner's experience